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Mobile *edoclink*: a mobile workflow and document management application for healthcare institutions

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Abstract

The exponential growth of mobile devices, like smart phones and tablets, has led to a growing ubiquitous computing paradigm, in which computing is distributed and available anytime, anywhere and supported by different devices.
The document and workflow management in organizations is made through computers connected to one or several servers via a networking infrastructure. The emergence of ubiquitous computing paradigm leads those solutions to be adapted for mobile platforms. Thus, users tasks can be done in a more efficient way due to the availability of information wherever they are using a mobile device, improving both the time needed to complete tasks and organizations' efficiency.
In this paper we present the mobile version of *edoclink* document and workflow management solution. *Edoclink* system was developed by Link Consulting© and is widely implemented in several healthcare institutions.

Keywords: Mobile development; Mobile health; Document management system; Ubiquitous computing; workflow management

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1. Introduction

Healthcare institutions have to prepare and process a growing amount of paper document. Some examples are the diagnostic tests, medical appointments and patient records. The nature of those documents makes them susceptible to be lost or damaged during its lifetime, mainly due to human action or accidents. Moreover, in healthcare institutions, like hospitals, the information needs to flow in real time, in particular if it is related to clinical episodes. This means that critical data has to be delivered to several players, such as doctors, nurses or administrative employees. These issues are part of a large amount of concerns, which underlie the document management and workflow management solutions.

A document management solution is an information system or a set of information systems responsible for capturing, managing, storing and distributing documents related to the business processes belonging to an organization. On one hand, the implementation of a document management solution optimizes the flow of documents between employees. On the other hand, these solutions eliminate the need of paper documents by making them electronic. Thus it is possible to suppress the problems related to paper format documents.

The document management solution *edoclink* [1] developed by Link Consulting© [2], is a renowned solution in Portugal and has a growing international expression. It has about 130 installations with more than 30000 users. This solution is implemented in several healthcare institutions like Administração Regional de Saúde do Norte (*ARSA*, *CHLO*), Saudaçor and Unidade Local de Saúde do Baixo Alentejo. In those organizations, *edoclink* solutions are responsible for the optimization of the administrative and expedient processes.

The *edoclink* solution is web-based, which means that it was designed to be accessed through a web browser in a computer connected to the network. With the exponential growth of the mobile devices, such as smart phones and tablets, the migration to a ubiquitous computing paradigm emerged, meaning that many computational tasks can be done anytime and anywhere with a mobile device.

This paper describes the development of mobile *edoclink*, a mobile solution that integrates with the existing *edoclink* solution. This mobile solution implements the access to workflow documents through a mobile device. It embodies access to documents information, documents, workflow and decision making while the user is on the go. It is thus intended to optimize workflows duration, leading organizations in general and healthcare institutions in particular to an improved performance when dealing with their business processes.

This paper is organized as follow. In Section 2 we present the fundamental concepts needed to understand the rest of the paper. We also summarize the state of the art in mobile document management applications and their integration with desktop solutions. We proceed in Section 3 with a description of the major features analyzed in the development of mobile *edoclink*. In Section 4 we describe the results we have obtained and finally, in Section 5 we delineate the conclusions for our work.

2. Background

This section comprehends the description of the main background knowledge need to understand the decisions we have made during the mobile *edoclink* development phase. We make a brief foray into the following subjects: *edoclink* document management solution, generic mobile computing concepts and state of the art mobile applications.

2.1. Edoclink document management solution

The *edoclink* document management system is intended to support the dematerialization of administrative and decision-making processes. It is developed on Microsoft© technology for a web environment, allowing easy access from any device that has an Internet browser. As it is intended to be implemented through the whole organization, this solution leads to a significant increase of efficiency and profitability due to the possibility of real time access to documents and making decisions. This solution also allows dematerializing documents and the associated processes and secure accesses to data, ensuring that users can only see the documents to which they have permissions.

With an intuitive interface, this solution has some key functionalities, namely the registry and classification of documents with versioning, the forwarding of documents with alarms and time controlled and the procedural organization of documents. Those functionalities lead to the following key concepts of *edoclink*:

- Document: digital copy of a document.
- Registry: entity containing one or more documents characterized by the process, classification, intervenient entities, antecedent and subsequent registries.
- Distribution: forwarding registries across the organization. This can be done from intervenient to intervenient or through previously defined routes.
- Process: document processing, which may contain registries, documents and distributions.

2.2. Mobile computing concepts

Despite the evolution on mobile devices [3], there are still several challenges related to their features and also to mobility. The challenges are mainly related to low computational resources when comparing to computers, devices can be stolen or lost, the bandwidth can be low or even be inexistent and the battery has to be recharged [4, 5].

In [6] the authors present three paradigms for mobile computing, namely mobile client adaptation, extended client-server model and remote data access.

Mobile client adaptation arises from the constant changes in environment faced by mobile clients. These changes can be a sudden lack of connectivity or a lack of local resources. The adaptation can be done in three different approaches, *laissez-faire, application transparent* and *application aware*. The *laissez-faire* approach consists on delegating the adaptation to the application. This can lead to a system collapse with all applications trying to allocate resources leaving no room for system essential tasks. The *application transparent* approach delegates the adaptation to mobile client. So, the resources are allocated by the system without a prior knowledge of the real application needs, which may lead to application resource starvation. The *application aware* approach lies within the previous approaches and consists on having the resources managed by the system that notifies the application about the available resources. By knowing the available resources, the application can request the resources it needs [4].

The extended client-server model [4, 7] was developed for trying to face network related problems, which means loss of connectivity, low bandwidth or low resources on the client. This model has three different approaches: *thin client, full client* and *flexible client.* In the *thin client* approach the processing is done on server side as in the *full client* the processing is done both on client and on server, with the client emulating server functions during disconnecting operation. The *flexible client* generalizes both *full* and *thin client* approaches with server and client roles changing sides according to application needs [6].

The remote data access consists in defining policies in accessing server data. These policies are intended to maintain data coherency, to define the technology used to retrieve data and data distribution policies. The data coherency can be achieved by saving all data versions on client, by saving only the last version and by saving the last version of data and updating when an amount of outdate data is reached [8]. The technologies used to retrieve data are *push* and *pull*. Both work similarly, differing on which side starts the communication.

Data distribution policies, presented in [8], are defined to distribute the most important data first, allowing users to obtain firstly the information they are looking for.

2.3. State of the art mobile applications

In what follows we describe the major functionalities and approaches used to ensure data security during the communication between the mobile application and the server, as well as the security of data stored in a mobile device. The reviewed applications are available at Android Market or Apple Store.

Alfresco Mobile [9] application is developed to the Apple's iOS operating system and allows users to view documents stored at an Alfresco document management system server. This application allows user to view the most recent version of a document, the information related with a documents set, such as the user who made the last modification, and also allows inserting comments about a particular document. It also allows the users to send a document as an e-mail attachment, open them in external applications and store the document on mobile device's internal storage for offline viewing.

The communications are secured by Hypertext Transport Protocol Secure (HTTPS) and the confidentiality of data is ensured with server authentication. There is no security on the mobile device, being possible to see the user's documents if the mobile device is compromised.

The OpenText Tempo [10] application was developed for iOS operating system and is part of the OpenText document management solution. It allows users to view the enterprise documents that are stored on the OpenText server on a mobile device. This application is widely used in healthcare institutions, providing a shared environment where doctors are able to access their patient records while nurses have access to patients under their care. This application ensures data confidentiality with server authentication, showing only the documents that the user has permission to access.

The Enprovia's mDMS [11] application, developed to Google's Android operating system and iOS, integrates with several document management systems that support the Web-based Distributed Authoring and Versioning (WebDAV) [12] document management technology, such as Alfresco and Microsoft SharePoint.

With this application a user can visualize and store for offline viewing the last version of a document. The security of data is ensured with encrypted communications and encrypted database on a mobile device. This application ensures data confidentiality with server authentication, showing only the documents that the user has permissions to access, and a pass code, asked whenever the user enters the application, to prevent unauthorized access to documents if the device is compromised. This application has no workflow support.

The Dynamics AX Workflow Approval[13] application, developed to the iOS operating system, allows Microsoft Dynamics CRM users to remote access their tasks. With this application the user can interact in workflows when indicated by another user approving or rejecting the received message and inserting comments. It is also possible to connect to different servers, allowing users to interact with several systems. The data confidentiality is made with Microsoft Dynamics AX server authentication and encrypted communications.

The iSaperion[14] is developed to the iOS operating system and is part of the Saperion software platform. It allows users to access organization documents and interact in workflows in a simple way. This means that users are able to see their tasks waiting for approval and can take decisions over them. It also allows users to see and add annotations related to documents. It connects to the server using secure connections to ensure data confidentiality.

Although the reviewed applications, shown on Table 1, have features that fit some needs of the *edoclink* mobile application, only the iSaperion implements all the key features needed in *edoclink*. Despite the iSaperion application implementing all the key features, the workflow management is done in a less complex way comparing to the *edoclink* needs.

Table 1. Mobile document management applications review

	Alfresco mobile	OpenText	Enprovia mDMS	Dyanamics AX Workflow Approval	iSaperion
Document management	Yes	Yes	Yes	No	Yes
Workflow management	No	No	No	Yes	Yes
Secure communications	Yes	Yes	Yes	Yes	Yes
Access Control to application	No	No	Yes	No	No
Data encrypted in client	No	-	Yes	No	-

3. Mobile *edoclink* prototype development

In this Section we present the considerations taken in account in the development phase of *mobile edoclink* application prototype.

In Figure 1 we depict the *mobile edoclink* application architecture. It is composed by the following three layers: data, business logic and user interface. The data layer has two sub-layers, namely the documents and database. The database sub-layer consists of storing all information related to distributions and documents. The documents sub-layer consists of storing the documents itself.

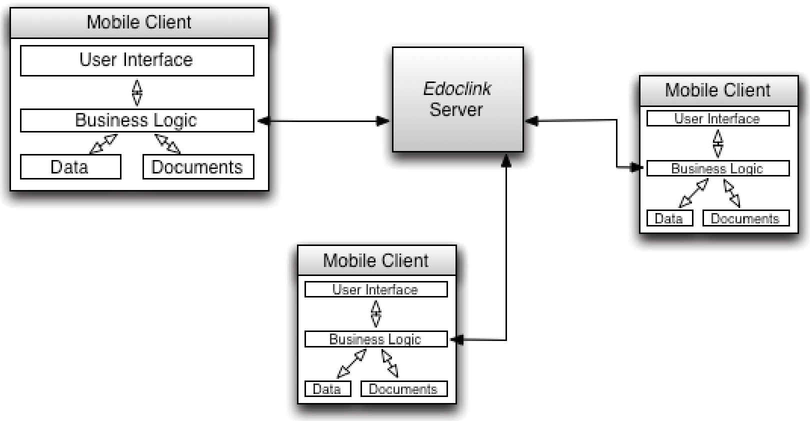

Fig. 1. Mobile *edoclink* architecture

The database uses the SQLite engine, as it is the database engine used by the most representative mobile operating systems. The documents are stored in separately due to its size and to avoid compromising the database stability.

The business logic layer has all the policies shown at section 2 as well as the application business logic. This layer is also responsible to communicate with the *edoclink* server.

The mobile client adaptation model chosen was the *application-aware* as it is the one that gives more guarantee concerning client operating system and application stability. Despite the adaptation made by the client, there is a need to define some policies in order to maximize the client resources.

To maximize the client's internal storage, the distributions are downloaded from the server based on a filter defined by the user. This filter defines which of the features are the most important to the user. That is, if the client runs out of available storage space, the update process is interrupted and it is ensured that the user has the most important distributions stored locally. The application has a maximum quota of local storage, defined by the user, which prevents it by using all the available storage.

Network resources are optimized, by downloading only the distributions that are not updated. Loading the distributions data alongside with documents name optimizes the mobile client memory usage. The documents are loaded only when the user wants to view them.

The mobile *edoclink* application is designed to support offline operation. That is, the application has to use the full client architecture, as it provides data stored on the client and the emulation of server functions to support offline operation.

Cache coherency is guaranteed through the last value policy, ensuring that mobile client only stores the latest version of data. Moreover, the mobile client searches for new versions of data when user accesses it. The last value verification is made when the user views a distribution. If there is a new version, it should be downloaded as soon as possible.

Data is acquired from server using the Pull technology to ensure the user receives only the last version of the distributions. This is done when the user starts the application, periodically as defined by the user or when the user views a distribution. These verifications depend on the availability of a network connection.

The security of the data on the mobile device is made with a pass code asked every time the user enters the application. On the other hand, all the communications are secured by the HTTPS protocol. This method ensures the confidentiality and integrity of data. The non-repudiation is ensured by the server authentication.

Table 2 summarizes the concepts and technologies that were chosen to be implemented in the mobile *edoclink* application.

Table 2. Prototype implemented technologies and concepts

Layer	Parameter	Technology/ Concept
-	Operating System	Google Android ®
Data	Database Engine	SQLite
Business Logic	Mobile Client Adaptation	Application Aware
	Cache Coherency Mechanism	Last Value
	Extended Client-Server Approach	Full Client
	Connections Security	HTTPS protocol
	Remote Data Access	Pull technology
	Confidentiality	HTTPS protocol Server authentication
	Non-repudiation	Server authentication

4. Results

In this section we present the results obtained so far with the development of mobile *edoclink*. We present the implemented features and the concepts described above. The results correspond to workflow as well as document management features and also application security.

Fig. 2 illustrates the mobile *edoclink* prototype main screen, where users can see their workflow waiting for a decision. It also shows the previous stages of the workflow, with the decisions taken by other users and also the next stages of the workflow.

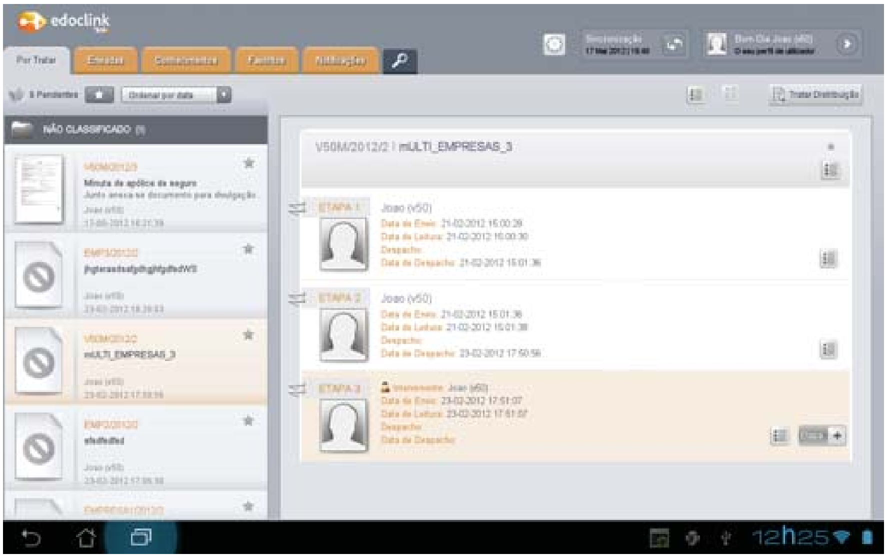

Fig. 2. Workflow management view

When the application is synchronizing with server, it gets new documents and distributions. The list that is shown on the left side is populated as the application gets new data. Users can then see the first and the most important distribution according to defined filters, as soon as they are available. Users can also mark a distribution as favorite, by making it always available on the mobile device.

When the user wants to view documents that are part of a distribution, the documents viewer appears, as shown in Fig. 3. In this viewer it is possible to see the current page and the thumbnails from other pages.

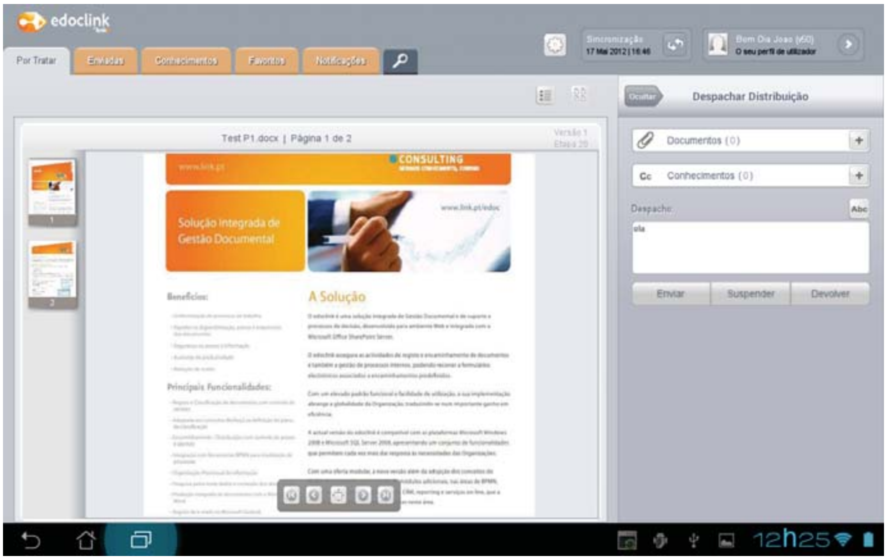

Fig. 3. Document viewer

Fig. 3 also shows the “dispatch area”, where the user can make decisions about the distribution. In this area the user is able to add attachments, add a text with his decision and send that information to the server. When the user leaves the application, these screens are hidden and a password is required to ensure that only authorized users only access the information.

5. Conclusions and future work

Edoclink document management solution itself leads healthcare institutions (e.g. hospitals) to improvements in productivity reducing costs. This is done by dematerializing information and reducing information delivery times due to the digital nature of documents. Although this is applied to all users within the institution, users with mobility needs can cause delays when they are part of workflows because they cannot have access to the *edoclink* standard version everywhere. Thus, the mobile *edoclink* solution was developed to allow users (e.g. doctors and nurses) to interact in workflows irrespective to the mobile device they have and, at the same time, to allow them to exchange critical documents related with patients, by using mobile devices.

To achieve these goals we have studied several mobile computing paradigms in order to avoid mobility related problems, such as battery lifetime issues, intermittent network connectivity and data security. Mobile *edoclink* application possesses the following interesting mobility concepts: *application-aware* adaptation, full-client architecture and last-value cache coherency mechanism.

The *application-aware* adaptation is of high importance to assure the stability of the operating system and, at the same time, the management of local resources and application needs. Thus, it is possible to the application to know the available resources and allocate them according to user’s needs.

The full-client architecture gives the application the ability to deal with intermittent network connections. This way, the application registers user operations, emulating server functionalities, and, when it has connectivity, sends the data to the server.

The last-value cache coherency policy tries to optimize the local storage, keeping copy of the last version of data only. This is possible to do in the database layer but the documents layer needs to store all documents because different versions of documents can be assigned to different distributions.

The development of mobile *edocink* application brings to light some challenges. Despite this application allows mobile users to interact with workflows, it lacks the ability to create new distributions as well as new processes and registers. In a healthcare environment, these functionalities would help to improve the efficiency of doctors who take care of people that are at their homes. By using such functionalities, doctors may start new workflows on the fly, instead of taking note and waiting to reach a computer to start the workflow. We are also planning to develop a mobile *edoclink* version for iOS devices, in order to increase the range of potential users that are able to use *edoclink* application.

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